STAFF SUMMARY SHEET

	TO	ACTION	SIGNATURE (*Surname*), GRADE AND DATE		TO	ACTION	SIGNATURE (*Surname*), GRADE AND DATE
1	DFR	sig	MABRY AD-25 20JAN12	6			
2	DFER	approve	Brent A Ruhl Col 27 Jan 2012	7			
3	DFR	action	(Author /Originator)	8			
4				9			
5				10			

SURNAME OF ACTION OFFICER AND GRADE	SYMBOL	PHONE	TYPIST'S INITIALS	SUSPENSE DATE
Michael Courtney AD-25	DFRL	333-8113	mwc	20120201

SUBJECT	DATE
Clearance for Material for Public Release USAFA-DF-PA-23	20120120

SUMMARY

1. PURPOSE. To provide security and policy review on the document at Tab 1 prior to release to the public.

2. BACKGROUND.
Authors: Jessica Abbott, Kerri Schmidt, and Michael Courtney

Title: Relative Weight of Brown Trout and Lake Trout in Blue Mesa Reservoir, Colorado

Circle one: Abstract Tech Report Journal Article Speech Paper Presentation Poster

Thesis/Dissertation Book Other: ________________

Check all that apply (For Communications Purposes):

[X] CRADA (Cooperative Research and Development Agreement) exists

[] Photo/ Video Opportunities [] STEM-outreach Related [] New Invention/ Discovery/ Patent

Description: Scientific paper.

Release Information: Posting at on-line repository (Cornell University Library and/or Nature Publishing Group)

Previous Clearance information: (If applicable) Not Applicable.

Recommended Distribution Statement: Distribution A: approved for public release, distribution unlimited

3. DISCUSSION. Not applicable.

4. RECOMMENDATION. Sign coord block above indicating document is suitable for public release. Suitability is based solely on the document being unclassified, not jeopardizing DoD interests, and accurately portraying official policy.

Michael Courtney

(signature)
Michael Courtney, PhD AD-25
Director, Quantitative Reasoning Center
Assistant Professor of Mathematical Sciences

1 Tab
1. Relative Weight of Brown Trout and Lake Trout in Blue Mesa Reservoir, Colorado

AF IMT 1768, 19840901, V5 PREVIOUS EDITION WILL BE USED.

Relative Weight of Brown Trout and Lake Trout in Blue Mesa Reservoir, Colorado

Jessica Abbott, Kerri Schmidt, and Michael Courtney
U.S. Air Force Academy, 2354 Fairchild Drive, USAF Academy, CO 80840
Michael.Courtney@usafa.edu

Abstract
Published data concerning the standard weight in lake trout (*Salvelinus namaycush*) and brown trout (*Salmo trutta*) have been established. The standard weights can be used to compute relative weights for data collected in the spring and summer of 2011 for brown trout and lake trout in the Blue Mesa Reservoir, Colorado. The mean relative weight of a sample of 100 brown trout ranging in length from 260 to 432 mm was 80.01 +/- 0.74, showing that the brown trout were in poor condition. The mean relative weight of a sample of 17 lake trout ranging in length from 387 to 689 mm was 86.57 +/- 2.40 showing that the lake trout were also in poor condition. Using least squares regression, a best fit curve was determined for weight (W) vs. total length (L) in the brown trout, $W(L)= 1000(L/517.49)^{2.5746}$, where W is in grams, and L is in millimeters.

Introduction
Blue Mesa Reservoir is a clear mountain reservoir located in Gunnison County, Colorado. It is the largest body of water in Colorado. This reservoir is also home to the largest kokanee salmon fishery in the United States. Lately, samples from the reservoir have been used to evaluate abundance and body condition of several different species of fish (Curecanti 2011). According to the samples taken, the abundant lake trout population have been causing a decline in the kokanee salmon population. The decline in the number of kokanee salmon has affected the lake trout and by stunting their growth from lack of food to support their population (Johnson 2011). This study reports the average relative weight of a sample of 100 brown trout and 17 lake trout as well as a weight vs. length relationship for the sample of brown trout.

Method
The lake trout and brown trout for the study were caught by sport angling. Accuracy for the measurements of the fish were +/- 2.3 grams for their weight and +/- 3 mm for the total length. The weight-length relationship in fish is represented by the improved model $W(L)= 1000(L/L_1)^b$, where L represents the total length (in mm) and W is the weight (in g). This model has been shown to yield smaller uncertainties in the parameters L_1, which is the typical length of the fish weighing 1 kg, and the exponent b. (Dexter et al. 2011, Keenan et al. 2011, Cole-Fletcher et al. 2011) If desired, the equivalent parameter *a* from the traditional model $W = aL^b$ can be computed as $1000L_1^{-b}$. The weight-length relationship is computed for brown trout using this model, but not for lake trout, because the exponent would be dominated by the single longest fish due to the sample size. The relative weight for the brown trout as well as the lake trout were calculated (relative to standard weights from Anderson and Neumann 1996), and the reported uncertainties are the standard errors of the mean. Some authors have taken exception to standard weights developed with the regression line percentile method (Gerow et al. 2004, Gerow 2010); however, the authors of the present study are unaware of a better comparison standard for these species.

Results
Figure 1 shows the graph of weight vs. length for 100 brown trout along with the best-fit weight vs. length curve and the standard weight curve. Most of the fish in the sample were significantly below the standard weight curve, and many were also below the best-fit curve for the 25th percentile weight vs. length data in Carlander (1969). The exponent in the best-fit model for the present study, $W(L) = 1000(L/L_1)^b$ is b = 2.5746 +/- 0.1235 which shows allometric growth of brown trout in the reservoir with the fish tending to become relatively more slender as they grow longer. The parameter L_1, which represents the typical length of a fish weighing 1 kg is 517.49

mm +/- 8.44 mm. This is much longer than the 450 mm which is the more common length of a fish weighing 1 kg (Carlander 1969).

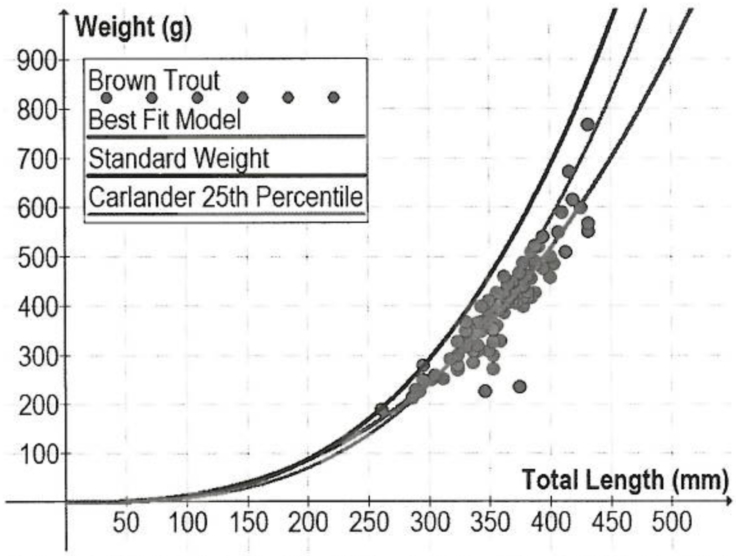

Figure 1: Weight vs. Total Length for brown trout in the Blue Mesa Reservoir with the best fit weight-length curve, as well as the standard weight curve for brown trout (Anderson and Neumann 1996) and the best-fit line to the 25th percentile data from Carlander (1969).

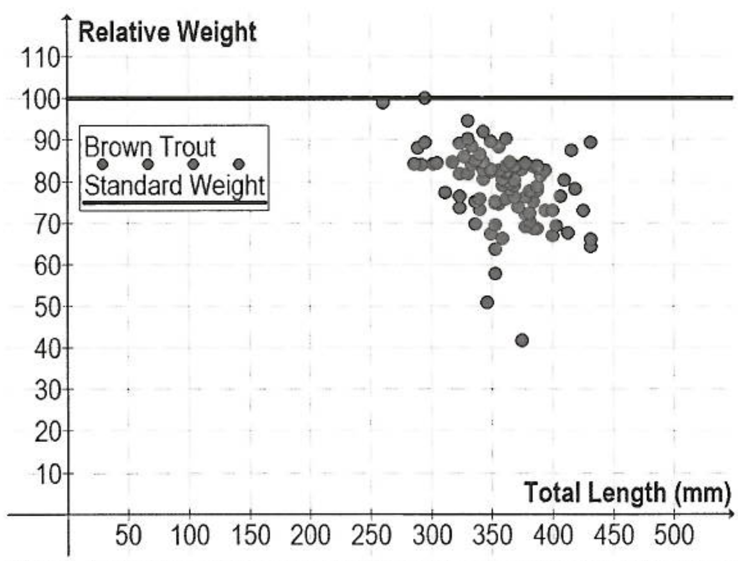

Figure 2: Relative weight vs. length brown trout in Blue Mesa Reservoir.

Figure 2 shows relative weight vs. length for 100 brown trout. Relative weights vary from 42 to 100, with an average of 80.01 +/- 0.73, as shown in Table 1. Simpkins et al. (2003) found that juvenile rainbow trout have a significant risk of mortality when their condition index falls below 80. The absence of many brown trout with relative weights below 60 suggests that a relative weight below 60 might have a high risk of mortality for brown trout in this length class. Relative weight can depend on length as the forage ability depends on the preferred food sources of fish as they grow. Care needs to be taken not to generalize the results for the length range of fish here (260-432 mm) to other lengths.

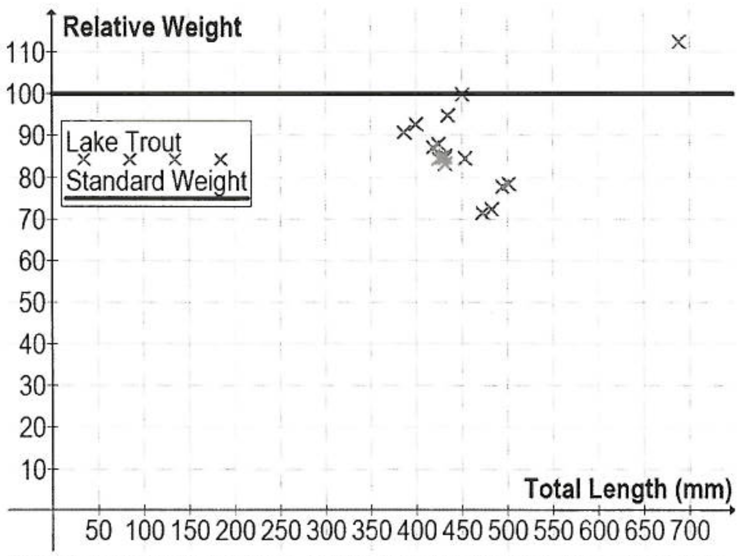

Figure 3: Relative weight vs. length lake trout in Blue Mesa Reservoir.

Figure 3 shows relative weight vs. length for 17 lake trout. The small sample size does not allow for definitive conclusions in isolation, but there is general agreement with a much larger study (Johnson 2011) which supports some observations. Relative weights vary from 71 to 112, with an average of 86.57 +/- 2.40, as shown in Table 1. It is notable that the 16 lake trout below or near 500 mm in length all have relative weights below 100, and that the only specimen with a relative weight above 100 is much longer at 689 mm. This is consistent with Johnson (2011) whose findings for lake trout in Blue Mesa Reservoir document a rapid increase in relative weight as fish get longer and find very few lake trout under 500 mm long with relative weights above 100; whereas, specimens with relative weights above 100 are common in most years for lengths above 650 mm. The number of "chunky" lake trout in Johnson's findings (see Figure 4, Johnson 2011) was small in 2009, but the relative weight for the longer lake trout was shown to increase in 2010 and 2011. These trends are ascribed to an overabundance of lake trout below 38 inches long, because the shorter lake trout eat mostly smaller fish for which there is too much competition with other small lake trout and the abundant brown trout in the reservoir. Once lake trout are large enough to eat the larger and abundant kokanee salmon in the reservoir, their relative weight quickly rises above 100. Johnson's work shows that relative weights above 130 are possible for the longer lake trout in the most productive years (2000, 2001, 2002, 2006). The Colorado Division of Wildlife seems to be attempting to manage the fishery to once again realize the potential for these fat lake trout.

Table 1: Mean relative weight, uncertainty, and length range for brown trout and lake trout. The uncertainty reported is the standard error of the mean.

Species	Mean Relative Weight	Uncertainty	Length Range
Brown Trout	80.01	0.73	260-432 mm
Lake Trout	86.57	2.40	387-689 mm

Discussion

In Blue Mesa Reservoir, the kokanee salmon population has been significantly reduced in recent years (Johnson 2011). Because the kokanee's decline matches the increasing weight loss in lake trout, one can conclude that the kokanee salmon are an important food source for larger lake trout. None of this is new information and a number of fisheries are finding it challenging to balance lake trout with kokanee salmon and rainbow trout fisheries (Johnson and Martinez 2000), since in the absence of other prey species (or few prey species as easy to catch and abundant as kokanee salmon and rainbow trout) the lake trout make it prohibitively expensive for wildlife managers to keep stocking sub-catchable fish only to have them eaten by the lake trout.

The most significant finding of the present study is the poor condition of the brown trout. The low relative weight of the brown trout and the additional comparison with the 25th percentile curve from Carlander (1969) suggest that the observation is not an artifact of how the standard weight curve was developed or attributable to a length-related bias in the curve. The brown trout seem to be more capable than rainbow trout and kokanee salmon of self-sustaining reproduction in Blue Mesa Reservoir (and the streams flowing into it) and also seem to be better than kokanee salmon and rainbow trout at avoiding predation from lake trout. As a result, the brown trout themselves have become overpopulated and unable to maintain optimal weights with the available food sources. The Colorado Division of Wildlife has become very aggressive in removing overpopulated lake trout in attempts to balance the fishery, both removing the limit on the number of smaller lake trout that can be kept by sport anglers and with netting operations. Perhaps aggressive management to reduce the numbers of brown trout is needed as well. If aggressive management is prohibitively expensive, liberal limits for anglers would be a positive step toward reducing abundance and increasing body condition.

Acknowledgements

The authors are grateful to BTG Research (www.BTGResearch.org) for supporting this work and to Joshua Courtney for valuable assistance weighing and measuring the fish. Joshua also brought the Simpkins 2003 reference to our attention and provided useful comments on the manuscript. The authors are also grateful to Dr. Brett Johnson (CSU) and Dr. Rich Marchand (USAFA/DFMS) for useful comments on the manuscript.

References

Anderson R.O., Neumann R.M., 1996. Length, Weight, and Associated Structural Indices, Pp. 461-480. *In:* Murphy B.E. and Willis D.W. (eds.) Fisheries Techniques, second edition. American Fisheries Society.

Carlander K.D. 1969. Handbook of freshwater fishery biology, volume 1., The Iowa State University Press, Ames, Iowa.

Cole-Fletcher S., Marin-Salcedo L., Rana A., Courtney M. 2011. Errors in Length-Weight Parameters at FishBase.org. Cornell University Library. arXiv:1104.5216v1.

Dexter M., Van Alstine K., Courtney M., Courtney Y. 2011. Demonstrating an Improved Length-weight Model in Largemouth Bass, Chain Pickerel, Yellow Perch, Black Crappie, and Brown Bullhead in Stilwell Reservoir, West Point, New York. Cornell University Library. arXiv:1107.0406v1

"Curecanti National Recreation Area (U.S. National Park Service)." U.S. National Park Service - Experience Your America. National Park Service U.S. Department of the Interior, 14 Sept. 2011. Web. Oct. 2011. <http://www.nps.gov/cure/index.htm>.

Gerow, K. G.,W. A. Hubert, and R. C. Anderson-Sprecher. 2004. An alternative approach to detection of length-related biases in standard weight equations. North American Journal of Fisheries Management 24:903–910.

Gerow, K. G. 2010. Biases with the regression line percentile method and the fallacy of a single standard weight. North American Journal of Fisheries Management 30:679–690.

Johnson, B. M., and P. J. Martinez. 2000. Trophic economics of lake trout management in reservoirs of differing productivity. North American Journal of Fisheries Management 20:127-143.

Johnson, Brett. "Sustaining Kokanee and Lake Trout at Blue Mesa Reservoir." Home. Colorado State University. Web. Oct. 2011. http://warnercnr.colostate.edu/~brett/lab/coldwater/BMR_MAC_KOK_000.htm

Keenan E., Warner S., Crowe S., and Courtney M., 2011. Length, Weight, and Yield in Channel Catfish, Lake Diane, MI. Cornell University Library. arXiv:1102.4623v1

Simpkins, D.G., Hubert, W.A., Martinez Del Rio, C., Rule, D.C. Physiological responses of juvenile rainbow trout to fasting and swimming activity: effects on body composition and condition indices. Trans. American Fisheries Society 132:576-589, 2003.

Weitendorf, Bob. "Kentucky Lake Fishing Measurement, Lake Barkley Fishing Measurement." Kentucky Vacations at Kentucky Lake & Lake Barkley. Kentucky Lake Fishing Measurement. Web. Oct. 2011. <http://www.kentuckylake.com/fishing/measurement.shtml>.